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Water Purification through Ion Exchange

Brittany Webb
Parkland College

WATER PURIFICATION THROUGH ION EXCHANGE

Unpublished research (done on a project in the SEAP program at the Army Corps of Engineers under mentor Dr. Kathryn Guy)

Clinoptilolite as an exchange site:

What is Clinoptilolite?

(Google images)

Rock/sand like

Naturally occurring zeolite (which means it can accommodate a variety of cations that can be exchanged for others)

Formula: $(Na, K, Ca)_{2\text{-}3}Al_3(Al, Si)_2Si_{13}O_{36}\cdot H_2O$

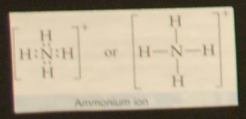
Found in the U.S. (Mojave Desert) (Koon et al., 449)

Selectivity of Clinoptilolite:

$Cs^+ > Rb^+ > K^+ > HN_4^+ > Ba^{2+} > Sr^{2+} > Na^+ > Ca^{2+} > Fe^{3+} > Al^{3+} > Mg^{2+} > Li^+$

Benefits

Clinoptilolite "selectively sorbs ammonium in preference to calcium, magnesium and sodium ions usually present in municipal wastewaters." (Koon et al., 449)



Can be reused (Koon et al., 448)

this means the clinoptilolite can be used quite a few times
Reuse = lower cost $

"Clinoptilolite is a natural cation exchanger and is known to have a high selectivity towards ammonium and potassium." (Baykal et. al., 2518)

This is good because municipal wastewaters usually contain high amounts of these!

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Background

- Forward Operating Bases (FOB) lack sustainable wastewater treatment systems
- This results in operational inefficiency, vulnerability and environmental degradation in the areas surrounding the bases.

Forward Operating Base

Clinoptilolite System Procedure

- On a load day:
  - 6.07×10^{-3} M solution of NH_4Cl is run through the system at 50mL/min
  - Samples are taken at optimal times so breakthrough can be recorded.
- On a regeneration day:
  - A solution of 10% by weight NaCl is mixed with NaOH to get a pH of 5.9 (the control, no NaOH is added) 11.7 (5.01×10^{-3} M), and 13 (10^{-1} M).
  - Then the solution is flushed through the system at 50mL/min
  - Samples are taken and analyzed at optimum times
  - Most ammonium ions are removed in the first 90 minutes, but the system is let run a full 8 hours to ensure a more complete regeneration.
- De-ionized water is flushed through the system in between each load/regen cycle.
- This flushes any residual sodium chloride and ammonia solution out of the system.

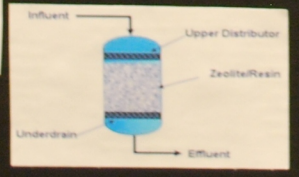
What is water purification through ion exchange?

Water purification is the "treatment of water to make it safe and acceptable for human use." ("Water Purification." Dictionary.com)

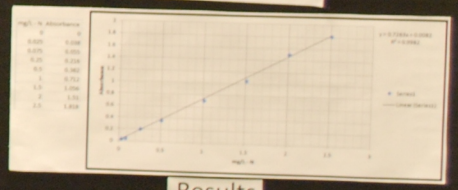
Ion exchange is "the process in which ions are exchanged between a solution and an insoluble solid, usually a resin." ("Ion-Exchange." Dictionary.com)

(Google images)

Water purification through ion exchange is the process of removing undesired contaminates from water through the exchange of ions between two electrolytes (or electrolyte solution and complex).



Calibration Curve

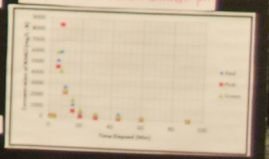


Results

Load: results, ammonium ions were run through the system

Load 6.11

Each of the colors are a different pH



Regen 6.12

Regen: results, the ammonium ions were flushed out of the system by a solution of NaCl + NaOH + water